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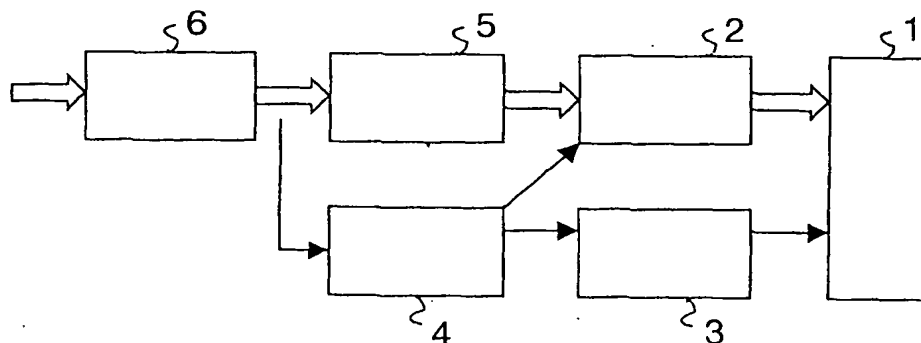
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**(54) Contrast and brightness control of a display**

(57) Controlling contrast and brightness of a display panel (1) by means of either a gamma correction unit or

a timing and control unit by controlling luminance of the display panel by varying a number of sustain pulses per second.



**FIG.6**

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**Description**

## Field of the invention

5 **[0001]** The present invention relates to the control of a display, and more particularly to contrast and brightness control of a display.

## Background of the invention

10 **[0002]** Today, many different types of displays exist. When looking at a display sometimes a user wants to adjust brightness and/or other settings of the display to get a better picture. Sometimes it is possible to change the environment instead, for instance to create a dimmed environment. Often a combination of adjusted settings and environmental conditions is used. Typical parameters that can be changed in the display are contrast and brightness. In common (digital) display systems, contrast and brightness can be regulated in the video stream before a gamma compensation has been performed. This can be represented by a formula, which includes gamma:

$$L_{out} = \{B + C \cdot (\text{Video}_{in} / 2^n - 1)\}^y \quad (I)$$

20 where

Video<sub>in</sub> = digital video input signal

L<sub>out</sub> = Luminance, light from display

B = Brightness offset ( 0 < B < 1, typical default B=0 )

C = Contrast factor ( 0 < C, typical default C=1 )

25 n = Resolution (number of bits, typical default n=8)

y = Gamma value (1 < y < 3, typical default y=2.4)

**[0003]** In a Plasma Display Panel, (PDP), a control unit can be used for controlling the consumed electric power of a display, for instance so that a brightness level is forcibly lowered to suppress consumption of power below a predetermined level. An Automatic Power Control (APC) unit avoids overloading the PDP (the panel and the power-supply of the PDP). In a conventional APC unit, typically the consumption of electric power is detected by detecting a mean current flowing through a high voltage power source that drives the PDP. Typically, the detected current value is compared to a reference value and periodically the APC unit modifies signals driving the PDP.

**[0004]** US-A-5 956 014 describes an analog brightness value set by a variable resistor that is converted into a digital brightness value.

35 **[0005]** When the APC unit is limiting the luminance of the PDP, contrast and brightness settings in the video stream will not have a predictable effect, while the APC unit will regulate to a new setting. This implies that optimal display performance cannot be obtained.

## Summary of the invention

40 **[0006]** It is an object of the invention to provide a method and apparatus for a display by which contrast and brightness control is improved. The invention is defined by the independent claims. The dependent claims define advantageous embodiments.

45 **[0007]** According to a first embodiment of the present invention, the object is realized by implementing contrast and brightness control in the video stream as a programmable Color LookUp Table (CLUT) unit, typically combining it with existing gamma and color point functions. This reduces the hardware cost and improves processing accuracy, since one quantization step can be omitted.

**[0008]** According to a second embodiment of the present invention, the object is realized by implementing contrast and brightness control independent from the video processing, close to the display.

50 **[0009]** According to a third embodiment of the invention, contrast and brightness are implemented in an existing power control unit, typically an APC unit that controls luminance of the display panel, typically a PDP. This provides optimal display performance with only little extra hardware cost. Furthermore, digital video processing is not affected since the unit is separated from the video processing.

55 **[0010]** According to a fourth embodiment of the invention, contrast and brightness regulations are performed in the APC unit by varying the number of sustain pulses per second. In this way, new settings will have a predictable effect.

**[0011]** Preferably, the brightness of the display panel is set by increasing or decreasing the number of sustain pulses (per time period) to a given sub-field of the display panel in accordance with a given brightness value.

[0012] These and other aspects of the invention will be apparent from and elucidated with reference to the embodiments(s) described hereinafter.

Brief description of the drawings

[0013] The present invention will be more clearly understood from the following description of the preferred embodiments of the invention read in conjunction with the attached drawings, in which:

Fig. 1 illustrates a PDP generating light.

Fig. 2 illustrates a PDP reflecting light.

Fig. 3 illustrates a PDP generating and reflecting light.

Fig. 4 illustrates a PDP generating, reflecting light and ambient light.

Fig. 5 illustrates how contrast and brightness can be combined with the gamma processing.

Fig. 6 illustrates the configuration of an AC-driven plasma display apparatus according to a preferred embodiment of the invention.

Detailed description of the invention

[0014] A PDP device, plasma display controller and plasma display driving method according to various embodiments of the present invention will now be described in detail with reference to the accompanying drawing figures.

[0015] In the following, a PDP device will be described; however it should be noted that this is only an example of a display type. Other types of displays typically other sub-field driven displays, for instance liquid crystal displays (LCDs) etc are also within the scope of the invention as set out in the claims.

[0016] A user is often equipped with a set of controls to adjust a display to a specific environment or to adjust video processing to personal preferences. In some displays, an automated process, driven by data from sensors might take care of the adjustment of the display for specific environmental conditions. Other displays will require the user to give feedback via the user controls. However, besides these adjustments, a user may like to change some settings to match with personal preferences, examples are for instance: color saturation, more contrast at specific grey-levels (for instance to see the back-ground of a horror-scene), histogram control or color-point (to get a warm or cool impression of an image). These are typical video processing features not correlated to environmental conditions.

[0017] The image quality of a PDP device depends on parameters such as: black-level, contrast ratio (dark room/dim surround/daylight), dynamic peak white (small area and short time), average peak white (large area and continuous), white point (e. g. D65), number of displayable grey-levels, and dithering. Contrast and brightness control are user settings, influencing the luminance and contrast ratio. This will be described below with reference to accompanying drawing figures 1-4.

[0018] In Fig. 1 it is illustrated a PDP 1 generating light (illustrated by arrows going out from the PDP). The contrast ratio (CR) follows the formula:

$$CR = L_{\max}/L_{\min} \quad (II)$$

where  $L_{\min}$  = minimum Luminance (light).

$L_{\max}$  = maximum Luminance (light).

[0019] In Fig. 2, the PDP reflects incident light ( $L_{in}$ ) as reflected light ( $L_{ref}$ ). The reflection ratio ( $r$ ) can be represented in a formula:

$$r = L_{ref}/L_{in} < 1 \quad (III)$$

[0020] In Fig. 3 the PDP generating and reflecting light is illustrated, whereby CR can be represented by a formula :

$$CR = n \cdot (L_{\max} + n \cdot r \cdot L_{in}) / n \cdot (L_{\min} + n \cdot r \cdot L_{in}) \quad (IV)$$

where

$n$  = filter plate transparency  $< 1$ .

[0021] If, as illustrated in Fig. 4, a PDP also is under the influence of ambient light ( $L_{amb}$ ), CR can be represented

by a formula as follows:

$$CR = \{n \cdot (L_{\max} + n \cdot r \cdot L_{in}) + x \cdot (L_{amb})\} / \{n \cdot (L_{\min} + n \cdot r \cdot L_{in}) + x \cdot (L_{amb})\} \quad (V)$$

where

$x$  = part of ambient light which affects the perception ( $0 < x < 1$ )

**[0022]** The formulas (III) - (V) show that  $L_{in}$  and  $L_{amb}$  reduce the theoretical CR. Moreover, they also show that  $L_{\min}$  should be kept as small as possible (generate less light during address and erase phase).  $L_{ref}$  can be reduced by reducing  $n$  in front of the panel, but this also reduces  $L' = n \cdot L_{\max} \cdot L_{in}$  and  $L_{amb}$  can be reduced by operating in a dimmed environment, i. e. closed curtains for instance.

**[0023]** A method of controlling a display panel according to a preferred embodiment of the invention will now be discussed. The method comprises the step of providing manual contrast and/or brightness control by controlling the luminance of the display panel.

**[0024]** This will be further described in the next formulas, which compare the effects of contrast and brightness regulation with processing in the video versus processing in the luminance domain:

$$L_{out} = \{B + C \cdot (Video_{in}/2^n - 1)\}^y = B' + C' \cdot (Video_{in}/2^n - 1)^y$$

**[0025]** Assuming  $y=2$  and  $B'=B^2$ ,  $C'=C^2$ , the formula becomes:

$$\begin{aligned} L_{out} &= \{B + C \cdot (Video_{in}/2^n - 1)\}^2 = B^2 + C^2 \cdot (Video_{in}/2^n - 1)^2 \\ L_{out} &= B^2 + 2BC \cdot (Video_{in}/2^n - 1) + C^2 \cdot (Video_{in}/2^n - 1)^2 = B^2 + C^2 \cdot (Video_{in}/2^n - 1)^2 \\ L_{diff} &= 2BC \cdot (Video_{in}/2^n - 1) \end{aligned}$$

**[0026]** When the brightness control  $B=0$ , the luminance difference  $L_{diff} = 0$ .

**[0027]** It can be proven that when  $B=0$  it does not matter whether contrast processing is done in video or luminance domain.

**[0028]** Preferably, the luminance of the display panel is controlled according to the formula:

$$Video_{out} = (2^n - 1) \cdot \{B + C \cdot (Video_{in}/2^n - 1)\}$$

where

$Video_{in}$  = digital video input signal

$L_{out}$  = Luminance, light from display

$B$  = Brightness offset

$C$  = Contrast factor

$n$  = Resolution

$y$  = Gamma value

or in an existing gamma correction unit, according to the formula:

$$L_{out} = \{B + C \cdot (Video_{in}/2^n - 1)\}^y$$

**[0029]** The control can also be provided according to an alternative formula:

$$L_{out} = \{B + C \cdot (Video_{in}/2^n - 1) - (D \cdot |(Video_{in}/2^n - 1) - E|)\}^y$$

**[0030]** A preferred embodiment of the invention will now be described, with reference to Fig. 5, in which it is illustrated how contrast/brightness control is provided in the video stream.

**[0031]** In Fig. 5 is a block diagram illustrating a preferred embodiment of a display system 10, provided with a PDP 1, a contrast/brightness controller 3, an automatic power control unit 4, a sub-field processor 2, a dithering unit 5, and

a gamma unit 6.

[0032] To reduce hardware requirement and to improve processing accuracy, contrast and brightness control can be combined with the gamma processing. It can be implemented as one LUT 8. Its content can be calculated off-line by a  $\mu$ -controller (not shown) and downloaded into the LUT 8.

[0033] A user might like to have the classic controls available, even if they would not be required for an optimal adjustment of the display. For PDP devices this would be the brightness control. To provide a user with a control, which will not deteriorate the image-quality, the classic effect can be replaced by another effect. For instance, it is possible to use a slight modification of the LUT content to provide more contrast in the dark areas of a scene, at the cost of contrast in the brighter areas.

[0034] In this case a user-controlled video-dependent luminance component is added to the normal luminance due to gamma to get a modified gamma curve which results in a higher contrast in darker areas (steeper gamma curve) and less contrast for brighter areas (less steep gamma curve).

[0035] An alternative embodiment of the invention will now be described, with reference to Fig. 6, in which it is illustrated how contrast/brightness control is provided in an automatic power control (APC) unit.

[0036] Fig. 6 is a block diagram illustrating a preferred embodiment of a display system 10, in the following referred to as a "display", according to another embodiment of the invention. The display 10 comprises a PDP 1 having display cells arranged in a X-Y orthogonal matrix, a processor unit 2, a contrast/brightness controller 3 and an automatic power control unit 4.

[0037] The PDP 1 is of conventional type and will therefore not be described in more detail since PDPs are well known. The contrast/brightness controller 3 is connected to the automatic power control unit 4, or can be a part of the same. Also software-only solutions are possible, provided that the contrast/brightness controller 3 is adjacent to or part of the power control unit 4.

[0038] In an AC-type PDP device, the data to be displayed is written for every line, and then the PDP is maintained by sustain discharges. The brightness of the PDP varies in proportion to the number of sustain discharges per time interval, and hence the brightness can be changed by the number of sustain discharges.

[0039] The automatic power control unit 4 modulates the consumed power of a display, in this embodiment the PDP 1. The generated light is regulated by changing the number of sustain pulses per second to the PDP. After image load of a frame has been determined, the light generated by the image can be amplified or attenuated, save guarding the PDP.

[0040] In a conventional PDP device, in case the APC unit is attenuating the image to reduce the power consumption or temperature, the luminance of the image is reduced. In this case, a user might try to change contrast/brightness settings to increase the luminance. When amplifying the video-data, the APC unit would immediately attenuate the image representation, back to the initial level but at reduced quality. This can be avoided by providing the contrast/brightness settings to the automatic power control unit according to the invention as implemented in the embodiment shown in Fig. 6.

[0041] Preferably, according to another preferred embodiment of the invention, the controller 3 can be arranged to provide for a user to set parameters to satisfy the user.

[0042] In this way, the digital video processing is not affected by the user-controllable contrast and brightness settings, since the settings are implemented after the processing has been performed in the processor 2. Therefore, it is possible to exploit the full available dynamic range for video data processing.

[0043] According to another preferred embodiment of the invention, the contrast and brightness of the PDP are set by increasing or decreasing the number of sustain pulses (per time period) to a given sub-field of the PDP 1 in accordance with the given values. This is a very accurate control mechanism, which gives an optimal and predictable adjustment.

[0044] An offset in the video-level due to brightness control according to formula

$$L_{out} = \{B + C \cdot (\text{Video}_{in} / 2^n - 1)\}^y \quad (I)$$

will generate a small color saturation artifact with respect to original image. This is not important when the brightness is adjusted to the black level of the display (for CRT the offset-current of an electron gun should be adjusted to get a just-noticeable video level "1"). Driving sustain pulses to a fully addressed display gives the effect of a classic brightness control. This can be achieved by addressing all lines at once instead of one-by-one, saving time.

[0045] For PDP, the brightness is typically set to "0", while a minimum luminance pixel is already clearly visible.

[0046] Amplifying the sustain level of sub-fields (C) resembles the effect of a contrast regulation. It can be noted that these variations are performed in the luminance domain instead of the video domain, however this has no impact.

[0047] Since the contrast/brightness controller 3 is implemented in the automatic power control unit 4, preferably in

a timing and control unit of the same (not shown), it can provide an optimal display performance, driven by software, with only little extra hardware cost.

**[0048]** When contrast and brightness control is done in the timing and control process, various timing aspects can be included. Temporary driving the display above the recommended automatic power control level can provide a better match with the user's demands.

**[0049]** Often a display supports a limited number of grey-levels, combined with dithering. When user-control and APC regulate the video level, for each pixel a course stepwise variation of the video level is calculated. The dynamic range of the video-data must allow increasing video-levels. In case of a user-control and APC regulating the sustain-level, variations on the sustain level step-size will cause variations of image representation at a more accurate resolution. In this case the video processing chain is independent of binary distributed sub-field weights. For Example: Video levels 1-2-4-8-16-64-128 related to e. g. 4-8-16-32-64-128-256-512 sustain pulses. 25 % reduction implies the following sustain levels: 3-6-12-24-48-96-192-384.

**[0050]** 10 % reduction (combined with temporal sustain dithering): 3,6-7,2-14,4-28,8-57,6-115,2-230,4 sustain pulses.

**[0051]** The invention can be realized by controlling contrast and brightness in a display panel by means of either a gamma correction unit, controlling luminance of the display panel by varying video levels, an automatic power control unit, already controlling luminance of the display panel by varying a number of sustain pulses per second, or a timing and control unit, controlled by software process which is already controlling luminance of the display panel by varying a number of sustain pulses per second.

**[0052]** It should be noted that the above-mentioned embodiments illustrate rather than limit the invention, and that those skilled in the art will be able to design many alternative embodiments without departing from the scope of the appended claims. In the claims, any reference signs placed between parentheses shall not be construed as limiting the claim. The word "comprising" does not exclude the presence of elements or steps other than those listed in a claim. The word "a" or "an" preceding an element does not exclude the presence of a plurality of such elements. The invention can be implemented by means of hardware comprising several distinct elements, and by means of a suitably programmed computer. In the device claim enumerating several means, several of these means can be embodied by one and the same item of hardware. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage.

## Claims

1. A method of controlling a display panel, said method comprising the step of:

providing manual contrast and/or brightness control by controlling the luminance of the display panel.

2. A method according to claim 1, wherein the contrast and/or brightness of the display panel is set by increasing or decreasing the video-level to a given pixel of the display panel in accordance with a given value, processed by a programmable lookup table, combined with gamma correction function.

3. A method according to claim 1, further comprising the step of:

implementing contrast/and brightness control independent from video processing, close to the display.

4. A method according to claim 3, wherein the control is provided in an existing automatic power control unit.

5. A method according to claim 1, wherein the contrast and/or brightness of the display panel is set by increasing or decreasing the number of sustain pulses (per time period) to a given sub-field of the display panel in accordance with a given value, preferably processed by software, and preferably combined with automatic power control function.

6. A method according to claim 5, wherein the brightness control is achieved by controlled light generation on the complete panel, during the erase phase of a display panel, typically a PDP.

7. A method according to claim 1, wherein the control is provided in an existing timing and control unit.

8. A method according to claim 5, wherein the contrast and/or brightness regulation is combined with a timing and control function.

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9. A contrast/brightness controller for controlling a display panel, arranged to provide manual contrast and/or brightness control by controlling the luminance of the display panel.
10. A contrast/brightness controller according to claim 9, wherein the controller is connected to or part of an automatic power control unit.
11. A contrast/brightness controller according to claim 10, arranged to control the luminance by increasing or decreasing the number of sustain pulses to a given sub-field of the display panel.
12. A display comprising a display panel, a sub-field processor, an automatic power control unit and a contrast brightness controller according to claim 9.

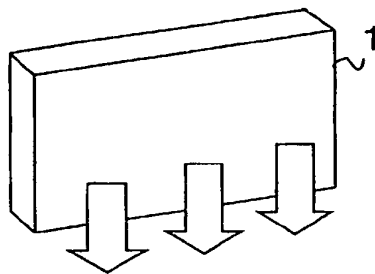


FIG. 1

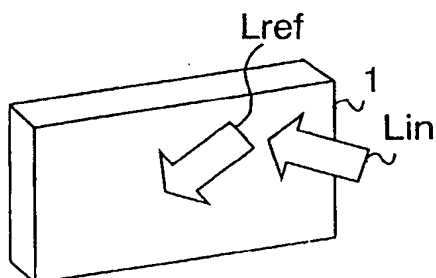


FIG. 2

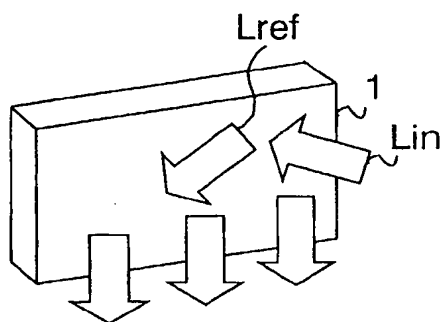


FIG. 3

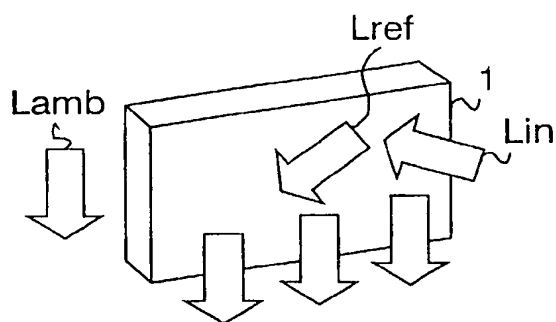


FIG. 4

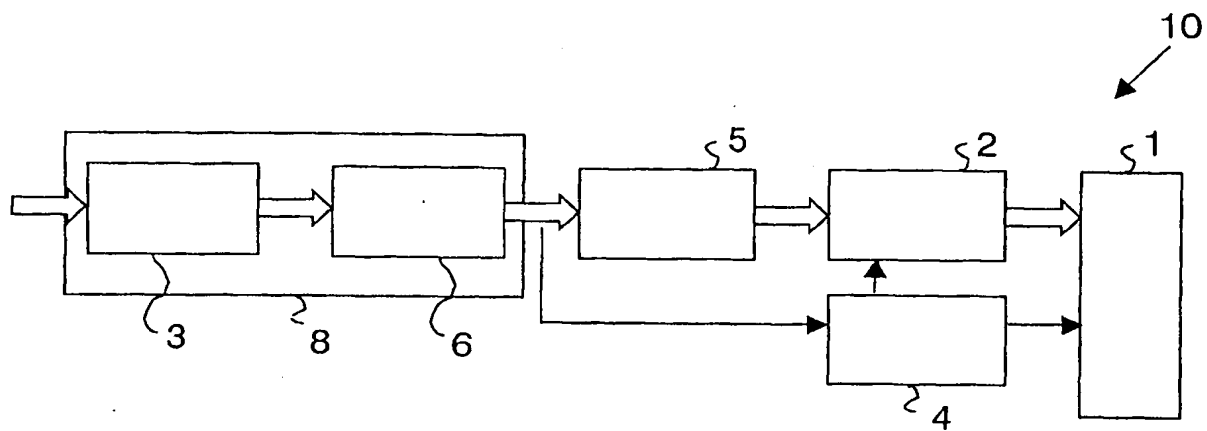


FIG. 5

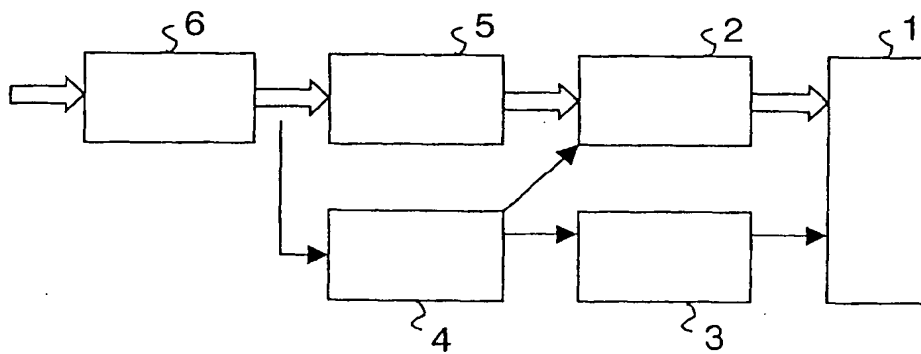


FIG. 6



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## EUROPEAN SEARCH REPORT

Application Number  
EP 02 07 6072

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	US 6 160 532 A (SAGAWA TAKAHIRO ET AL) 12 December 2000 (2000-12-12) * column 13, line 56 - column 14, line 21; figures 1,7 *	1-3,9	G09G3/28
X	US 5 757 343 A (NAGAKUBO TETSURO) 26 May 1998 (1998-05-26) * column 2, line 8 - line 56; figure 2 * * column 8, line 39 - column 10, line 7; figure 10 *	1,3-5, 7-12	
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			TECHNICAL FIELDS SEARCHED (Int.Cl.7)
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The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 30 August 2002	Examiner Amian, D
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